Space Weather Forecast

Issued on Thursday, 15 September 2022 at 13:15 Local

This forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: CME arrived, chance Minor Geomagnetic Storm in immediate term, probably sustained by succeeding fast solar wind. Minor/Moderate Radio blackouts likely, but risk falling later in weekend.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was low in the past 24 hours, but notably with a Moderate-class X-ray flare shortly preceding the period observed from the largest and most complex sunspot at 14/1018UTC. The largest flare of the current reporting window was an upper-end common-class observed from the same spot group at 14/1216UTC. Analysis of this group is starting to be compromised by the narrowing viewing angle near the solar horizon, however it appears to be areally shrinking, with mobile intermediate spots that appeared to become fewer in number.

Also of note in terms of flares was a long-period northwestern solar horizon common-class flare observed at 15/0633UTC. This is considered likely to be the progenitor of a Coronal Mass Ejection (CME), however satellite imagery is not yet available to confirm this, and in any case any Earth trajectory is considered relatively unlikely from such a position.

In total there were up to four sunspot regions on the Sun. In addition to the aforementioned large and complex group, there were two other spots with potential large spans, as well as a much smaller and more diffuse (apparently) unipolar collection of spots.

No new Earth-directed CMEs have been observed on available imagery, although there was a slow possible 'filament eruption' observed around 15/0730UTC from the west central portion of the Sun. Any CME is not yet apparent but will be monitored. In addition, imagery from the previously mentioned northwest solar horizon event is awaited.

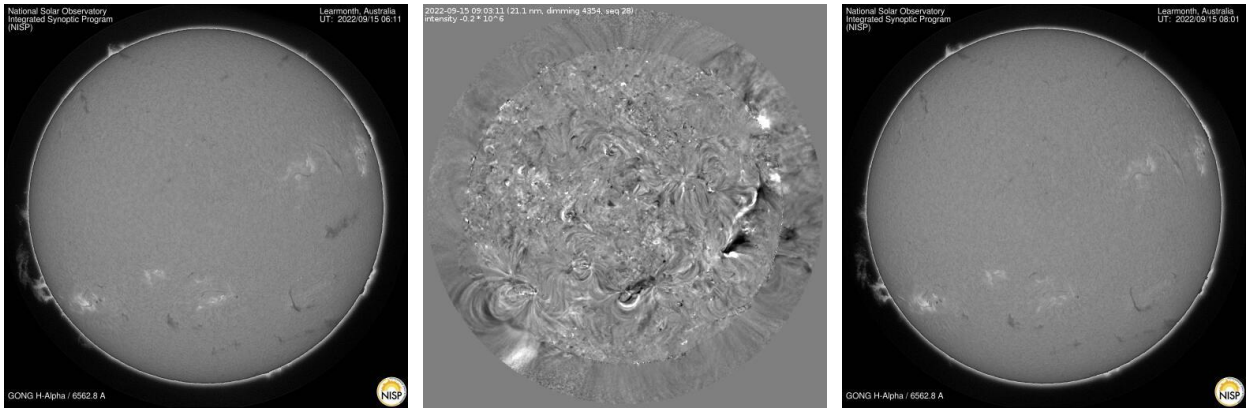

Figure 1: Near infrared imagery from a ground-based observatory either side of an extreme UV image (courtesy SIDC ROB) - all showing a 'disappearing filament' (a new possible CME source) west of the centre of the Sun. This event is being monitored for.

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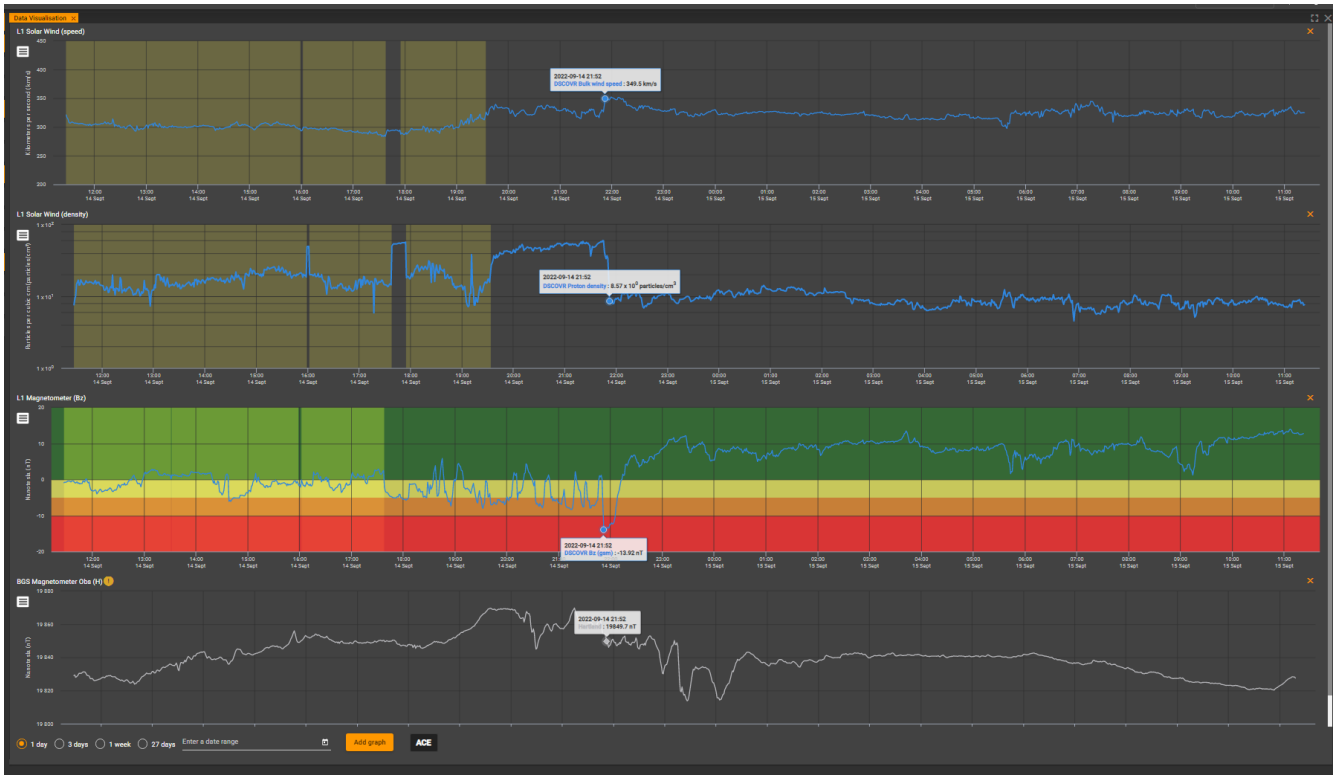
Solar Wind / Geomagnetic Activity: The solar wind trace was initially symptomatic of possible very minor CME contamination or a nominal slow regime, but notably interrupted by the arrival of a stronger and more definite CME at during the UTC evening and overnight period.

The initial perturbations were relatively blunted, but the solar wind started to change in earnest from about 14/1900UTC in the possible shock, with the sharpest gradients in solar wind measures observed at 14/2150UTC. There was no single magnetic sudden impulse of sufficient scale recorded at Earth-based BGS magnetometers to warrant an alert in the period, however the Hartland horizontal component did approach changes of approximately 30nT at times (three occasions) in reaction to the CME (with sizes nearer 50nT+ typically leading to such alerts).

Figure 2: Top: MOSWOC visualisation of solar wind speed as recorded by observing satellites around a million miles form Earth on the Sun-Earth line (the Sun is roughly 93 million miles away). Also shown are the number of particles in the solar wind (density) and north-south component of their inherent magnetic field (with the green area being co-aligned). The bottom graph is BGS's Hartland magentometer, with deflections generally of around 30nT at peak. The main magnetic cloud-like signature can be seen to be nascent from 14/2150UTC, with Bz forecast to possibly smoothly decline into negative territory later today – to greater geomagnetic effect.



While conjectural, there is a possibility that this is the awaited faint CME emitted on 09 September. This had no obvious source region when observed, but was inferred from satellite imagery, with a postulated arrival time of 15/0001UTC - i.e. it has arrived two hours early. Perhaps supporting this hypothesis is the unusually slow subsequent solar wind speed - barely changed from prior to the arrival, although the CME analysis itself is on the lower limit of physicality to escape the Sun at all. The apparent precision of this estimate belies large error bars given uncertainties in the analysis (not least by being unable to confirm a source). It is also accepted that other minor CMEs may be responsible.

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Should the above not be the cause, there is also the possibility that this is the arrival from a more obvious 'filament lift off' of Sunday 11 September. This was not visible beyond the immediate solar environment, severely hampering analysis (in many ways the opposite problem to the 09 September event).

The solar wind speed started the period at background levels, before undergoing a slight increase with the arrival of the CME after 14/2150UTC. The number of particles comprising the solar wind showed a concurrent strong peak before a precipitous drop to background levels thereafter. The associated magnetic field was mostly small-scale but turbulent prior to the main CME signature, before a sharp increase to elevated levels in the wake of the CME. The north-south component of the magnetic field came in anti-aligned with Earth's field in the immediate aftermath of the CME, before a rapid, and so far lasting, switch to become co-aligned.

The net result of the above solar wind measures was provisionally two successive intervals just below Minor Geomagnetic Storm G1 - this was obviously heavily moderated by the chance thus-far favourable co-aligned magnetic field

Energetic Particles / Solar Radiation: While no solar radiation storms have been observed in the period, slightly elevated proton levels have been seen throughout, with a slight downward trend from a peak near 2.5pfu (where 10pfu is S1).

Figure 3: Top: the past week in solar radiation (blue trace), showing occasional sub-S1 level enhancements (S1 being along the very top of the plot). Also shown (below) is X-ray flux, with no strong potentially causative correlation seen between the two plots, perhaps suggesting far side activity is at least in part responsible (also perhaps hinted at by the gradual proton level rises).

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity is likely until day three, with a step-wise reduction through day three (Sunday 17 September) as a result of the largest and most active sunspot group leaving the Earth-facing side of the Sun on this day. No notable regions are due over the eastern solar horizon

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to compensate, and likely Moderate-class flares become only a chance by the end of the period.

Solar Wind / Geomagnetic Activity: The (probable) only CME in the forecast has arrived and its effects are ongoing. Whatever the cause, the anti-aligned portion of the CME's magnetic field (with Earth's) is felt unlikely to be finished, and a gradual drift into this sector is expected over the coming 12-18 hours or so. This will probably prolong the risk of G1 over this period, especially during the UTC evening and perhaps the early hours before finally abating into daybreak of day two, Friday 16 September.

Figure 4: Suggested total magnetic field (blue) and north-south component (white) evolution in the coming hours – likely to be more impactful overnight UTC than levels seen at present.

The fast wind from a succeeding 'coronal hole' should follow later on day two, giving a resurgent chance of Minor Geomagnetic Storm G1, partitioned between this and the following UTC day, before finally abating to quiet conditions through day four, Sunday 18 September.

Energetic Particles / Solar Radiation: There is a daily slight chance of S1 - mainly the result of the most complex region moving through its most geoeffective solar longitudes in the period - a risk should it flare appropriately. This is coupled with the current higher-than-typical baseline level of activity.

Geomagnetic Storms:

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	40	30	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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Radio Blackouts - X Ray Flares:

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	No	60	60	40	25
Very Active	R3 to R5 X	No	5	5	5	1

Solar Radiation Storms - (High Energy Protons):

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	15	15	15	15
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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